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Requirements for an Aircraft Carrier Flight Deck Fire Fighting Test Facility

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14. ABSTRACT
This report outlines the requirements for a flight deck fire fighting facility. This includes mock aircraft, flush deck nozzles, AFFF delivery system, and wind machines. Environmental issues are detailed.

15. SUBJECT TERMS
Fire fighting; Aircraft carriers; Flight deck fire threats; Mini-deck

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CONTENTS

REQUIREMENTS FOR AN AIRCRAFT CARRIER FLIGHT DECK FIRE FIGHTING TEST FACILITY

1.0 BACKGROUND

The CVNX Live Fire Test and Evaluation (LFT&E) surrogate testing program includes a task entitled "Vulnerability of Hangar Bay and Flight Deck." Under current plans, the flight deck analysis and associated testing occurs in FY-07. A recent executive summary of the fire protection and recoverability LFT&E efforts for CVNX [1] stated that detailed plans for flight deck testing would be provided in a future up-date. If past practice is any indication, such testing would necessitate the existence of a simulated carrier deck test bed.

All current flight deck firefighting systems and hardware were initially proof-tested, and subsequently refined, based on large-scale fire tests on simulated carrier decks. Most of these test series were conducted at NAWC China Lake, CA, or to a lesser extent at other test sites such as the test pad at the Naval Research Laboratory (Washington, D.C. and Chesapeake Beach). Most of these tests used artificial wind generation to simulate normal flight deck wind speeds. Wind was generated by the use of aircraft propeller wash and/or air boat fans. Examples of carrier related large-scale tests that have been conducted in the past are as follows:

- NAS Jacksonville, 1968: initial conceptual testing of a modified flight deck washdown system [2]
- Naval Research Laboratory (NRL), 1969: possible applications of AFFF on flight decks [3]
- NAWC China Lake, 1970: preliminary "mini-deck" testing of proposed flight deck firefighting enhancements [4]
- NRL, 1971: flush deck nozzle evaluations [5]
- NAWC China Lake, 1972: confirmation of firefighting ability against S-2 aviation gasoline hazard [6]
- NAWC China Lake, 1979: evaluation of deck edge nozzles [7]
- NAWC China Lake, 1982-83: multi-series "Nimitz fire tests" [8]
- NRL, 1984: testing of prototype firefighting robots [9]
- NAWC China Lake, 1985: tests of pop-up and improved flush deck nozzles [10]
- NAWC China Lake, 1986: testing of proposed bomb farm system [11]
- NRL, 1991: fire hazards of mixed fuels on flight deck [12]

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Due to the likelihood that any future flight deck vulnerability assessment will also include large scale testing, it is prudent to perform an assessment of the requirements for a properly designed test bed. Follow-on detailed test bed design and construction would need to be initiated at least two years prior to actual testing.

2.0 OBJECTIVE

The objective of this report is to define the requirements for a large-scale test bed for assessing CVNX flight deck fire threats and vulnerabilities. The test bed would also be available for evaluating potential flight deck fire protection improvements and/or advanced firefighting concepts, including manned intervention.

3.0 SCOPE

This report will address generic test bed requirements, which might apply to construction of a brand new facility, as well as required modifications to the existing "mini-deck" at NAWCWD China Lake, CA.

4.0 CURRENT CVN FLIGHT DECK FIREFIGHTING SYSTEMS AND EQUIPMENT

The specifications for the CVN-76 (currently under construction) provide details on the current design of aircraft carrier flight deck firefighting systems and equipment [13]. There are 20 AFFF flush deck washdown groups, a separate system (Group # 21) for the bomb farm on the starboard side of the island, and 22 AFFF hose stations (both 2 ½ inch soft hose and 1 ½ inch hose on reels). Details are as follows:

- The entire flight deck is protected by a zoned array of flush deck nozzles. Each group, which provides a nominal flow of 1000 gpm, can be activated remotely from control panels in both PRI-FLY and the Pilot House. The specified nozzle is Grinell Type SB, with a rated flow of 30 gpm @ 30 psi. Nozzles are nominally spaced one per 500 square feet of flight deck area, for a design application rate of 0.06 gpm/ft^2.

- Areas of the flight deck close to the edge of the deck are also protected by deck edge nozzles that discharge inboard through the coaming. The currently specified nozzles are Bete Model ¾ NF30080X (straight stream) and Bete Model ¾ NF30030 (spray pattern), each rated 30 gpm @ 80 psi. Nozzles are installed every 12.5 feet along the deck edge perimeter, and arranged so that the nozzle spray patterns alternate in successive nozzles from straight stream to spray. The intent is to provide an additional AFFF application rate of 0.08 gpm/ft^2 within 30 feet of the deck edge.

- Each washdown group that is adjacent to an aircraft elevator has deck edge nozzles designed to spray AFFF onto the elevators (two nozzles at each outboard fore and aft edge of the elevator) when the elevator is at the flight deck level. These nozzles are designated as Bete 1NF40080X (straight stream pattern) rated 30 gpm @ 80 psi.

- A separate zone protects the bomb farm on the starboard side of the island. The system can be activated from controls mounted on the exterior of the island, as well as from controls panels in FLIGHT Deck Control, PRI-FLY, and the Pilot House. This system consists of inward spraying nozzles mounted at the deck edge (same nozzles as the deck edge nozzles described above). Two nozzles are installed every 8 feet (alternately 5 feet and 3 feet apart).

- Every point on the flight deck must be reachable by a minimum of two AFFF hose stations. Except for the forward most stations on the front end of the bow (which only have a single 1 ½ inch hose reel), each station consists of both a 2 ½ inch and a 1 ½ inch hose. Each 2 ½ inch AFFF hose is equipped with a vari-nozzle rated at 250 gpm, while each 1 ½ inch hose has a vari-nozzle rated at 125 gpm.

- AFFF solution flow rates for each flight deck demand point are as follows:

AFFF System	**Nominal Flow Rate**
Flush Deck/Deck Edge Group	1000 gpm
Bomb Farm System	900 gpm
AFFF 2 ½ Inch Hose	250 gpm
AFFF 1 ½ Inch Hose	125 gpm

- Additionally, there are a minimum of two P-25 flight deck fire fighting vehicles on each flight deck during air operations. Each P-25 has a 500 gpm turret and a 95 gpm handline. Design of a test bed should provide a driveable surface to accommodate the use of a P-25 in test scenarios.

- The current operating doctrine for these systems [14] specifies that the initial response to any flight deck fire would consist of the P-25s and hoses deployed from the closest AFFF hose stations. For any fire deemed to be beyond the capability of the immediate response teams, or for any multi-plane conflagration, the AFFF washdown system would be activated (the group in the fire location as well as the group immediately upwind).

Though CVNX unique features could necessitate modifications to the current systems and operational doctrine, as a starting point a flight deck test bed should provide the capability to duplicate the features cited above.

5.0 GENERIC REQUIREMENTS

The following outlines general requirements for flight deck firefighting test facilities. The system specifications cited above and tests conducted in the past, were used as the baseline in establishing requirements.

Figure 1 shows a conceptual design of a facility. While this design was used to construct a training facility, the basic concepts would, to a large extent, also apply to a test bed used for evaluation of aviation fire threats and flight deck firefighting.

Table 1 describes attributes of a generic fire test facility. The requirements have been separated into two categories. The "desired/optimum" identifies requirements if a separate facility was being designed from scratch, specifically for Naval aviation threats. The "minimum" requirements recognize needs based on adaptation of an existing design or facility.

Key requirements for adapting an existing facility include:

a. Minimum size – 370 m^2 (4,000 ft^2)
b. Fuel/water/AFFF storage and pumping capability, and resulting containment/drainage/recycling/removal requirements
c. Need for installed AFFF systems (flush deck, deck edge, and hoselines)

The installed AFFF flush deck system should be similar to the design described in paragraph 4 above. This would have a significant impact on the deck design/construction. Since this is a "mature" technology/system, there may not be a critical need for further testing. However, it may be a key factor for any integrated LFT&E tests involving aircraft carrier flight deck firefighting, especially if unique hazards (new fuel, aircraft or ordnance) are anticipated for CVNX, or if there are changes to the overall flight deck arrangement. If intermediate deck drains are installed in the test pad, they might be adapted to accommodate flush deck piping and nozzles. Alternatively, low-level systems might be constructed on an as-needed basis. They may not necessarily be "flush", i.e.; they could be surface mounted.

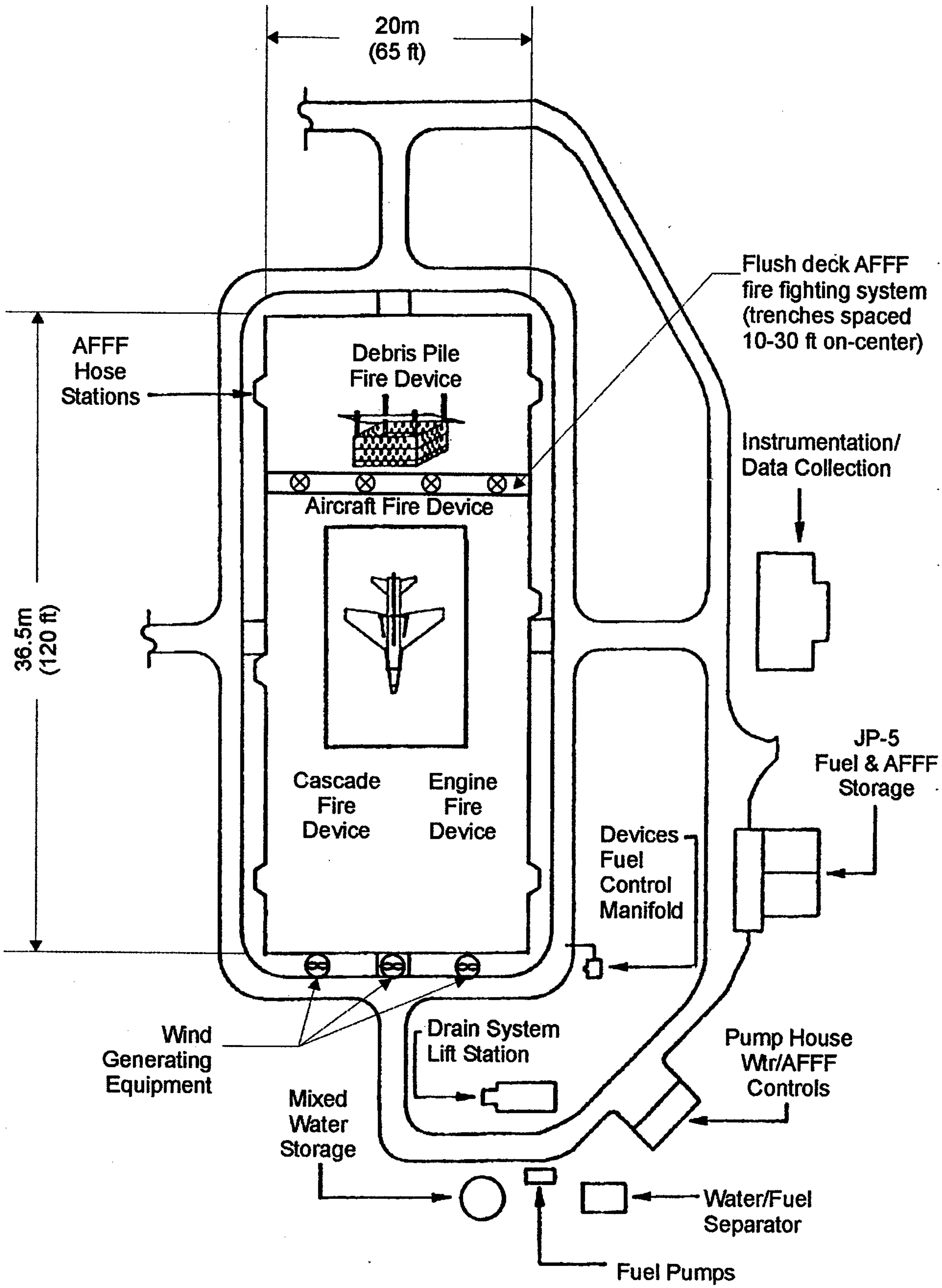

Fig. 1 – Example fire test facility

Table 1 - Facility Requirements

Attribute	Optimum Requirement	Minimum Required	Comments
1. Test Area			
a. Size of area	740 m^2 (8,000 ft^2) plus apron	370 m^2 (4,000 ft^2)	See Figure 1
b. Substrate	Steel, designed for multiple uses without warpage	Relatively flat concrete (see item 1d)	The steel design may not be practical. Concrete is typically used for test/training pads. Consider concrete with "sacrificial" layer of gypcrete or similar material which can easily be repaired/replaced if spalled. Caution: any water runoff from previously fueled concrete surfaces must be treated as hazardous waste.
c. Orientation	Long axis positioned with prevailing wind	None	
d. Drainage	Fixed grate drainage within deck and around perimeter	Single point drain(s)	

Table 1 - Facility Requirements (continued)

Attribute	Optimum Requirement	Minimum Required	Comments
2. Firefighting systems			
a. Water pumping [assuming simultaneous flush deck, deck edge, hose lines, and 1900 Lpm (500 gpm) miscellaneous demand]	7,600 Lpm (2,000 gpm) fixed, in-place	Portable equipment, 5,700 Lpm (1,500 gpm)	Fixed would be ideal but not required - tank/hydrant capacity is important, e.g., in the range of 15,200 L (4,000 gal) per test, 4 tests/day = 60,800 L (16,000 gal) per day
b. AFFF			
(1) Flush deck system with a 2.46 Lpm (0.06 gpm/ft^2) application rate (plus upwind row of nozzles) and deck edge nozzles 3.81 m (12.5 ft) apart	Flush deck nozzles installed in deck (e.g., trenches) and deck edge nozzles on one side	Alternative low-level system, installed as needed. Deck edge nozzles on one side.	Anticipated high cost/impact; may also need to investigate environmentally improved AFFF
(2) Hose reels 3.8 cm (1.5 in.)	4 – 475 Lpm (125 gpm) fixed around perimeter	1-4, 475 Lpm (125 gpm) portable, as-needed	
(3) Hose baskets 6.4 cm (2.5 in.)	4 – 950 Lpm (250 gpm) fixed	1-4, 950 Lpm (250 gpm) portable, as- needed	
(4) AFFF solution	Proportioning system 7,600 Lpm (2000 gpm), or pre-mix tank with 30,400 L (8000 gal)	Pre-mix tank with 22,800 L (6000 gal) solution capacity	

Table 1 - Facility Requirements (continued)

Attribute	Optimum Requirement	Minimum Required	Comments
3. Auxiliary Systems			
a. Fueling	Fuel storage and pumping for approx 10,600 L (2,800 gals)	Fuel tanker for pool and 190 Lpm (50 gpm) for running fuel provided as-needed for each test series	Alternative to minimum requirement - a single fixed JP-5 tank of 11,400 L (3,000 gal)) which could be drained and filled with a different fuel blend, as-needed; pump could be fixed or portable
	Minimum fuel tank size of 22,800 L (6,000 gals)	5320 L (1,400 gals) per test	
b. Power	Fixed, with outlets at test bed	Portable generator(s)	
c. Wind generation 0–30 knot capacity across deck	Aircraft props or portable from wind machines	Portable wind machines - minimum 4	Alternatively, provide from props of salvaged aircraft

Table 1 - Facility Requirements (continued)

Attribute	Optimum Requirement	Minimum Required	Comments
4. Environmental Control			
a. Liquid effluent (fuel and AFFF/water)	103,400 L (27,200 gal) total per day; design based on 10,600 L (2,800 gal) fuel: pool fire plus 2 min, 190 Lpm (50 gpm) debris pile), plus 15,200 L (4,000 gal) water/AFFF per test 4 tests/day: 4 x 25,800 = 103,400 L per day (27,200 gals per) day	66,900 L (17,600 gal) total per day; design based on 5,320 L (1,400 gal) fuel and 11,400 L (3000) gal water/AFFF per test. 4 tests/day: 4 x 16,700 = 66,900 L per day (17,600 gals per day)	A number of options and combinations are available, including oil/water separation, recirculation of "gray" water, tank storage removal, and AFFF removal by mechanical separation/aeration - Plan on high side of effluent flow instead of low side.
b. Smoke production	740 m^2 (8,000 ft^2) pool fire and 190 Lpm (50 gpm) running fuel	370 m^2 (4,000 ft^2) pool fire and 190 Lpm (50 gpm) running fuel fire	

Table 1 - Facility Requirements (concluded)

Attribute	Optimum Requirement	Minimum Required	Comments
5. Test articles			
a. Debris pile	Construct hardened article, fixed piping, as part of test site	Construct as part of specific test series	See reference [8] for details
b. Aircraft mock-up	Constructed hardened article, fixed piping, as part of test site	Construct as part of specific test series	
c. Instrumented dummy ordinance	Prepare as fixed asset	Construct as needed for specific test series	See reference [8]
6. Instrumentation Fuel flow, water flow, wind speed and direction (fixed and portable) thermocouples (100 max), radiometers and calorimeters (10 each), video, data collection system	Prepare as fixed asset	Bring as needed for each test series	"As-needed" probably is acceptable and efficient method

Additional requirements, such as test articles and instrumentation, are included primarily for informational purposes. It is anticipated that much of this equipment would be provided on an as-needed basis for specific test series.

6.0 REQUIRED UP-GRADES TO THE EXISTING CHINA LAKE "MINI-DECK"

6.1 History of the "Mini-Deck"

Construction of the original "mini-deck" at China Lake was begun in 1969 following the flight deck conflagration aboard *USS Enterprise* (CVN-65). During initial testing in 1970 the fire area was only 2180 ft^2. Later that year the fire area was expanded to approximately 7500 ft^2. Because the site lacked a water supply, water was stored in two 6,000 gallon tanks. Pre-mixed AFFF was stored in a separate 10,000 gallon tank, and delivered under pressure to the fire area by fire department pumpers. Normal flight deck wind was simulated by the prop wash of a C-97 aircraft positioned approximately 150 feet forward of the fire area. The C-97 contained four piston driven propellers about 20 feet apart. Wind speeds of 0 - 30 knots at the leading edge of the fire area were obtainable by varying the speed and pitch of the propellers. Flush deck nozzles were fed by a combination of surface mounted pipes as well as a few recessed pipe channels. Deck edge nozzles were fed by surface mounted piping and fire hoses. AFFF and water hoses were fed directly from the pumpers. A steel aircraft mock-up, with a continuous running fuel fire, was used in most tests, often with instrumented underwing dummy bombs to relate fire extinguishments to cook-off times. In some series, actual derelict aircraft fuselages were distributed throughout the fire area to enhance realism. After each test, residual fuel, water and AFFF were drained to an open pit behind the fire area. Accumulated fuel was burned off in place.

For the Nimitz test series beginning in 1982, the concrete area surrounding the fire pit was expanded and two new 60,000 gallon water/AFFF tanks were added, along with diesel driven fire pumps to augment fire department pumpers. For some testing the wind pattern was expanded by the use of scaffold-mounted airboat fans and gas turbine driven wind machines rented from a Hollywood special effects contractor. Metered underground supply mains were used to determine AFFF flow to flush deck nozzles installed in the fire zone and upwind zone. Figure two is a photo of the "mini-deck" during the Nimitz test series in 1983.

Late in the 1980s, the C-97 was replaced by a P-3A (Orion) turbo-prop aircraft and the concrete apron was expanded. To meet environmental restrictions, the unlined drainage pond behind the fire area was replaced with a lined evaporation pond located across the road on the west side of the deck. Within the past few years there have been three major changes: (1) the base water supply main was extended past the "mini-deck" and a new fire hydrant was installed adjacent to the deck (2) an oil water separator was installed to replace the evaporation pond, and (3) the aircraft was removed.

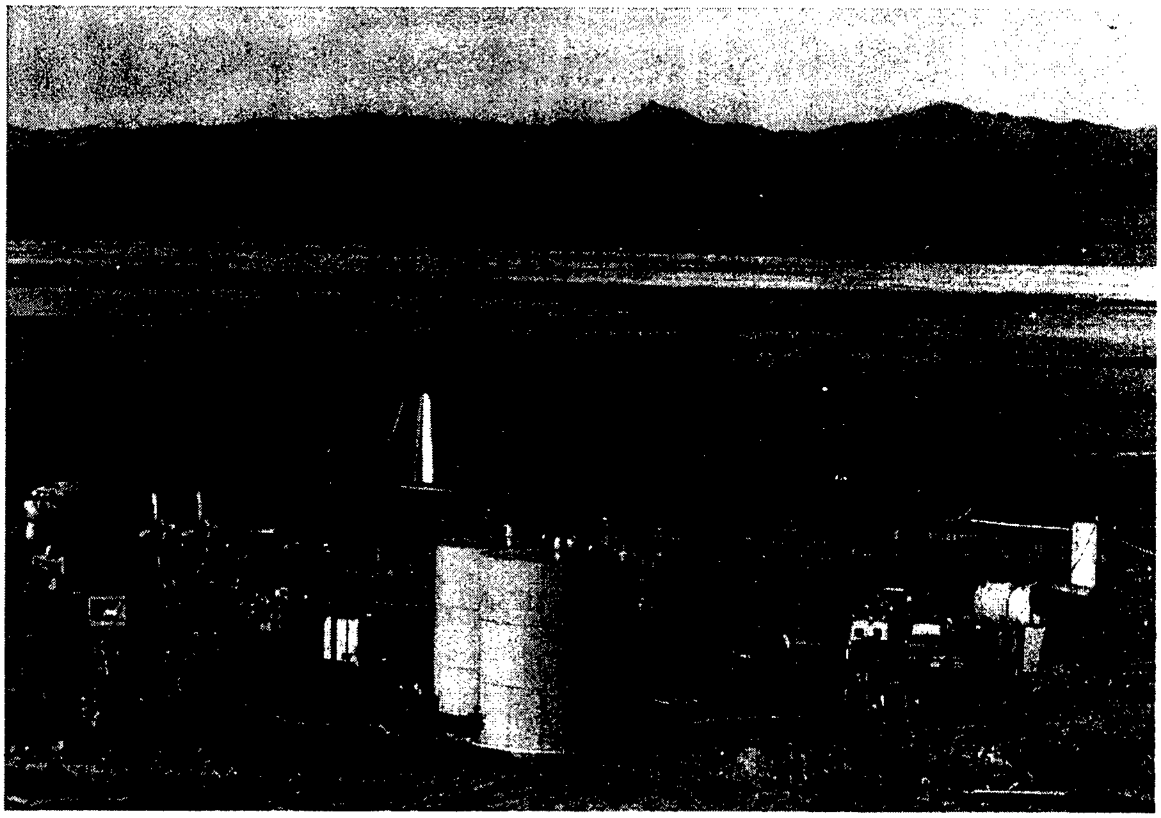

Figure 2 – China Lake "Mini-Deck" during Nimitz tests

6.2 Current Status of the "Mini-Deck"

Figs 3 and 4 show the current configuration of the "mini-deck". The recessed fire area is approximately 90 feet by 82 feet. An extensive concrete apron surrounds the fire area. The apron slopes toward drainage troughs that carry liquid effluent to the oil/water separator. Pipe troughs, which could be used to carry feed pipes for flush deck nozzles, cross the fire area. On the west side of these pipe troughs there are drain lines that allow liquid from the deck to flow into the bottom of the drainage troughs. Fig 5 and 6 show the pipe troughs that cross the fire area. Each of these pipe troughs is covered with removable steel plates. Fig 7 shows the grated drainage trough that feeds the oil/water separator on the west side of the fire area. Fig 8 illustrates how the fire area is recessed from 1-2 inches within the surrounding apron.

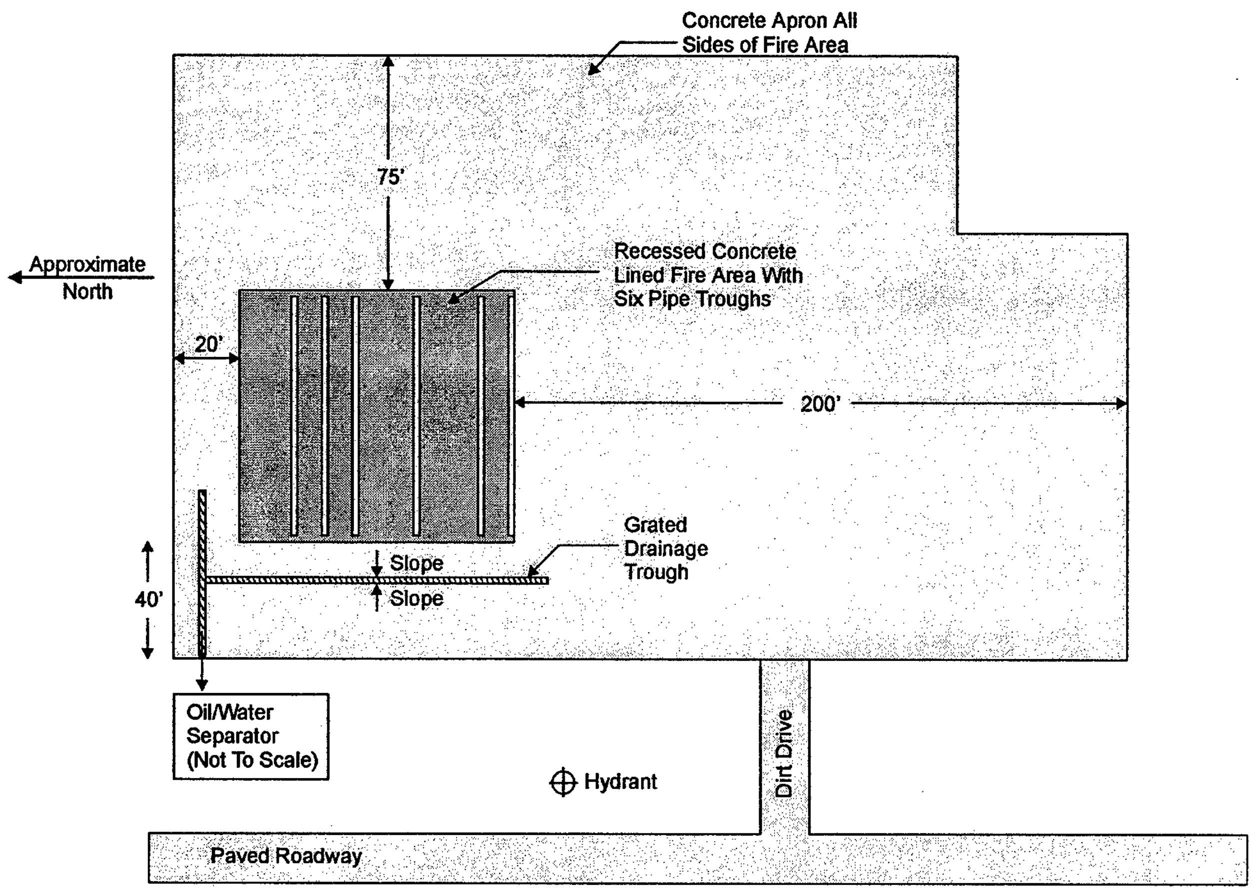

Figure 3 – Current China Lake "Mini Deck"

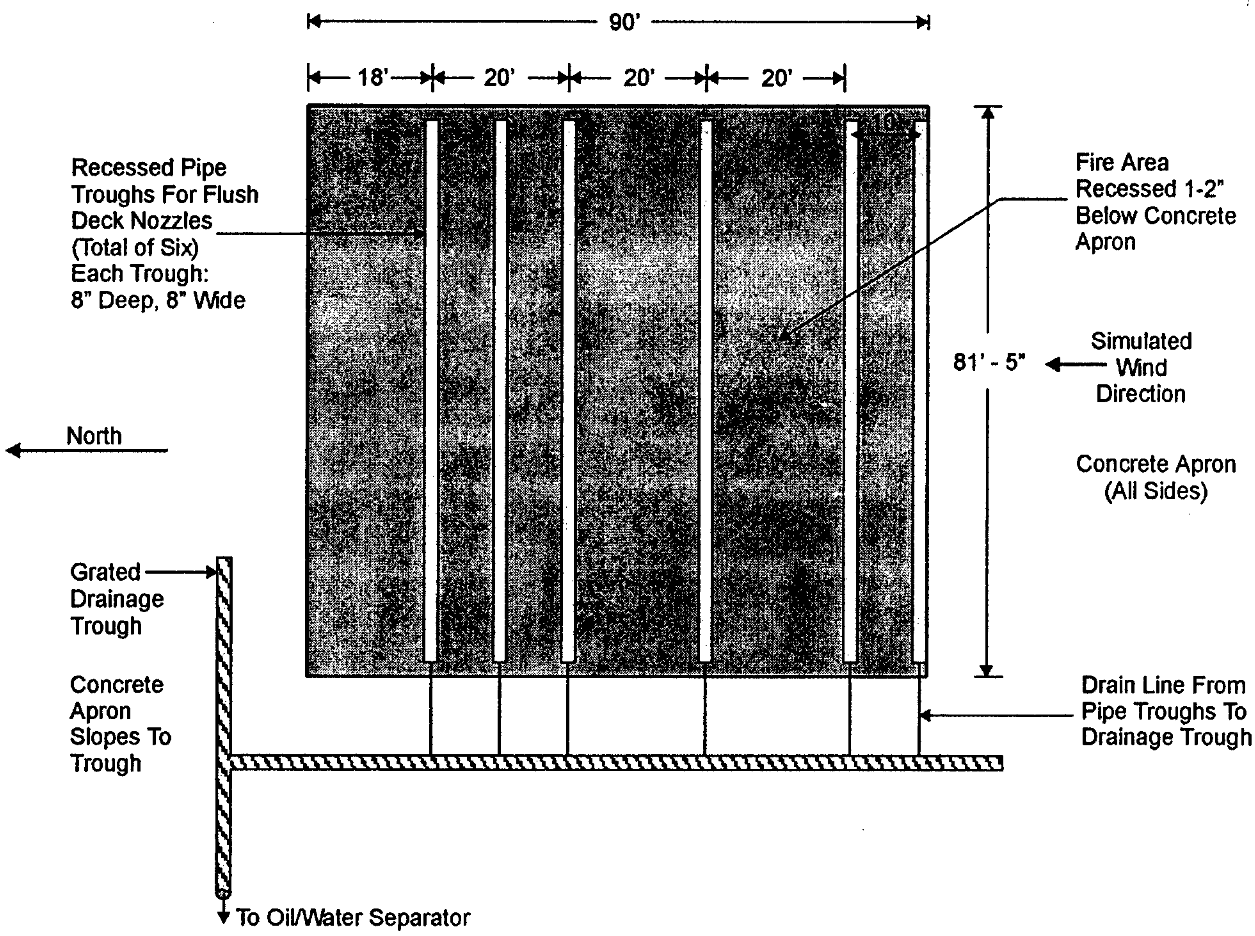

Figure 4 – Recessed fire area

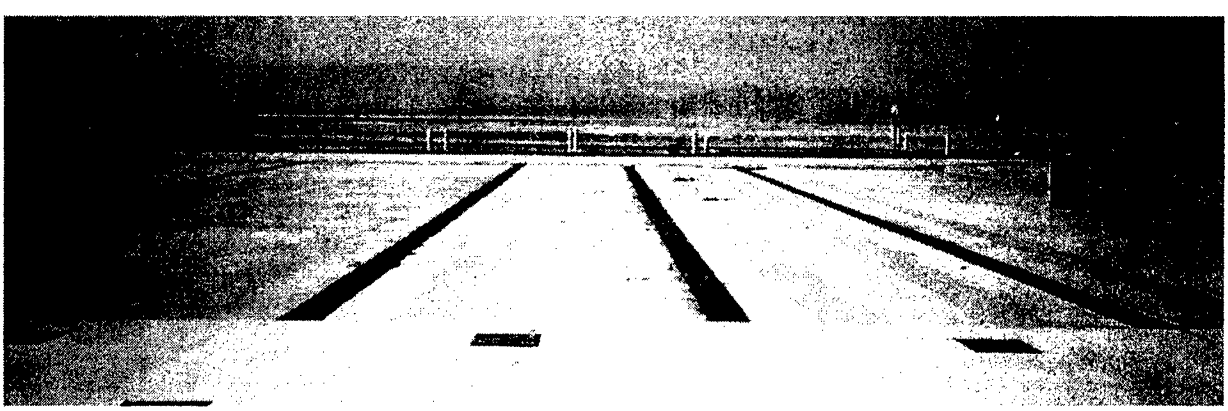

Figure 5 – Photo showing pipe troughs (looking from east side of deck)

Figure 6 – Photo looking northeast (oil/water separator top left)

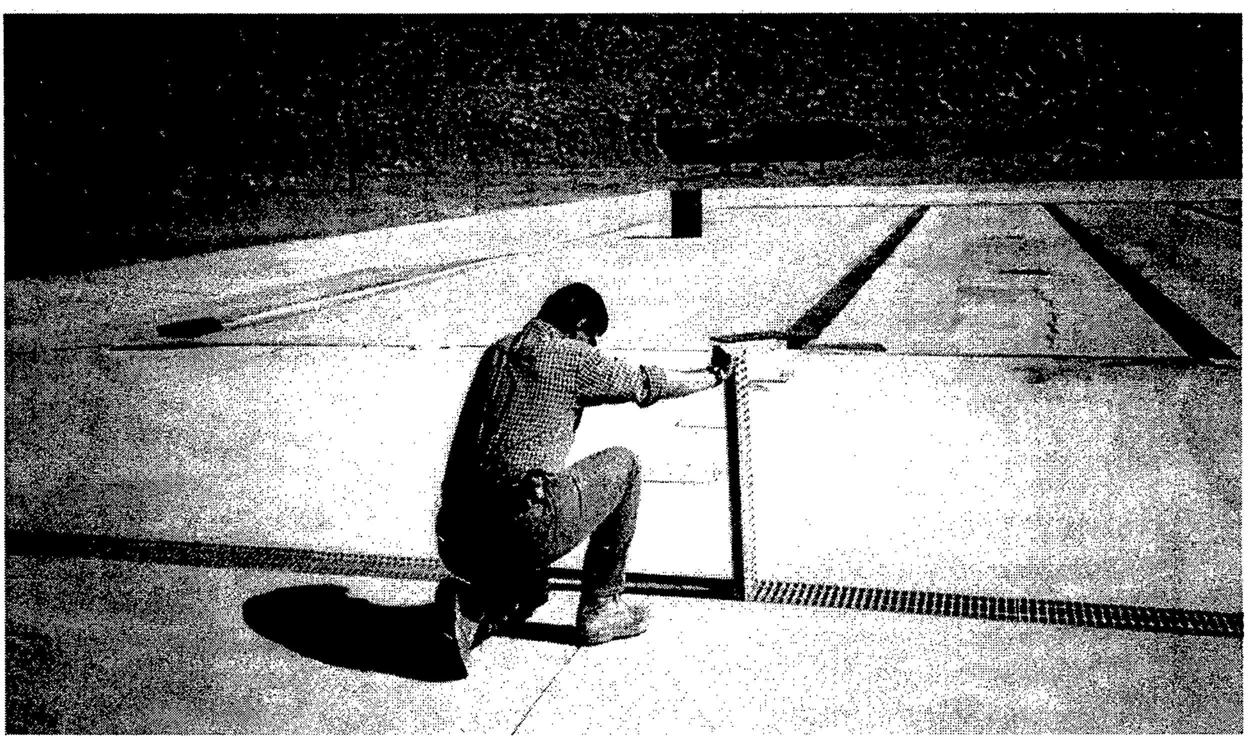

Figure 7 – Grated drainage trough on west side of deck

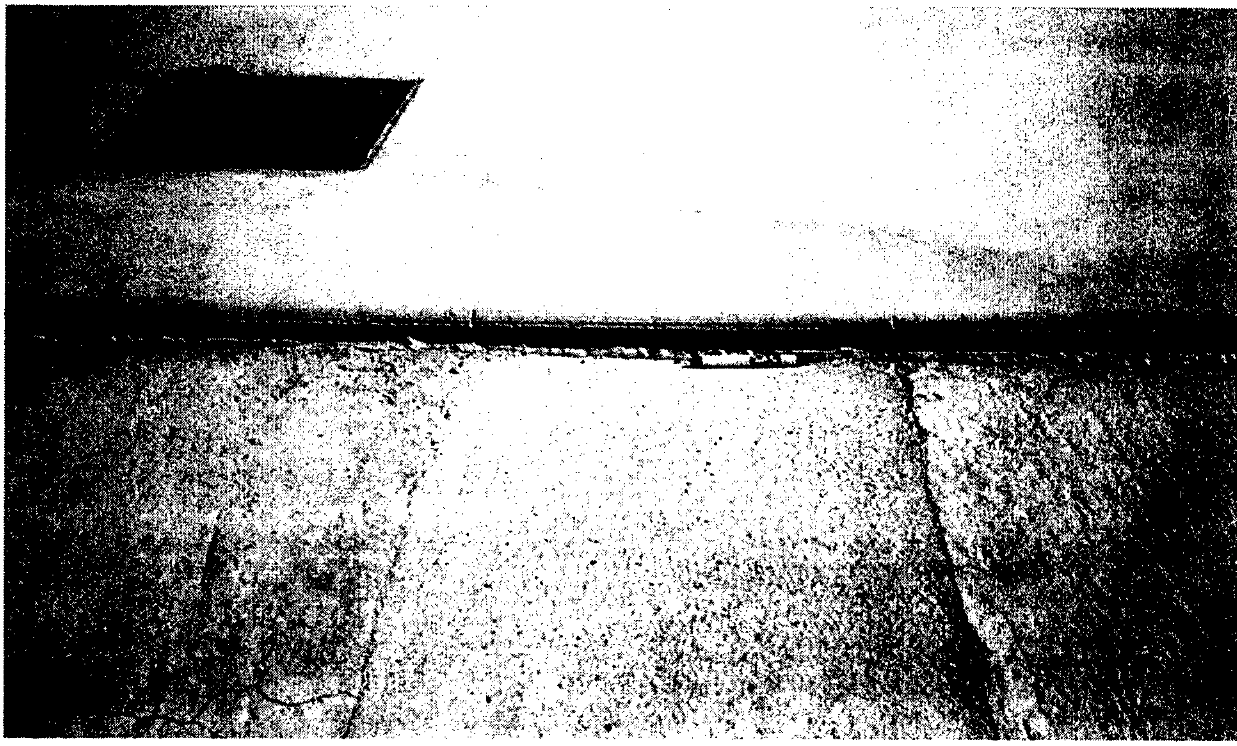

Figure 8 – Photo showing fire area recessed below apron

The primary author of this report visited the site during the last week of September 2002. Based on that visit, the status of the "mini-deck" could be summarized as follows:

- The oil/water separator appears to be functional.
- A piped water source is available at the site (the approximate location of the existing fire hydrant is shown in Fig 3). The available flow capacity and pressure at the hydrant is unknown.
- Original underground piping has been abandoned and is not considered to be functional. The expanded concrete apron covers the original supply piping.
- There is no wind generating capability.
- The entire fire area, and surrounding apron, is constructed of concrete, but the tightness of the concrete surfaces has not been confirmed. The ability of the concrete to prevent seepage of fuel and AFFF into the ground below is the biggest unknown relative to environmental suitability.
- All concrete surfaces are driveable and will adequately support vehicles such as P-25s for testing or pumper trucks for water/AFFF delivery.
- There are no installed pumps or foam proportioning system in place.
- All original water/AFFF storage tanks are still in place, though their internal condition/functionality is not known.
- Electric power is available at the site.
- Pipe troughs, that originally carried the distribution piping that fed the flush deck nozzles, are empty. Additionally, there are no deck edge nozzles or hose reels, though

these could be easily installed and fed by surface piping or supply hoses. Fig 9 is a close up view of an existing pipe trough (each trough is approximately 8 inches in width and 8 inches deep). Fig 10 is a sketch showing how flush deck and deck edge nozzles could be fed by surface supply mains running along the east and west sides respectively. These supply mains could be fed by either surface piping or fire hoses run from a stationary pump or pumper truck.

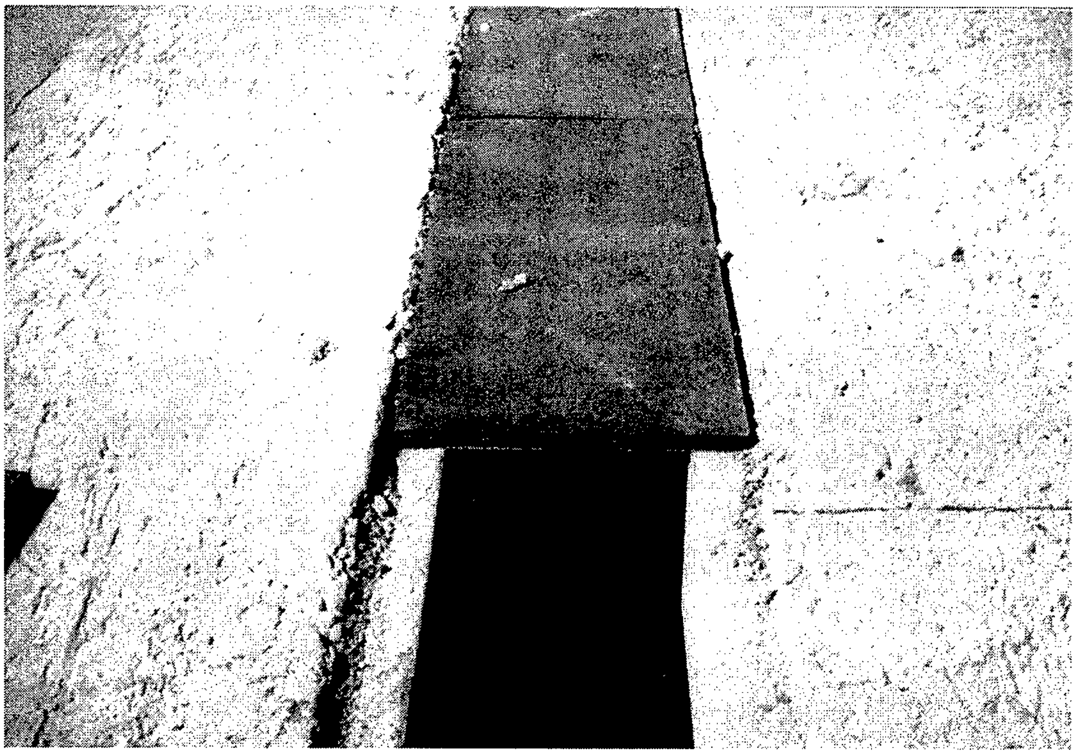

Figure 9 – Close up photo of pipe trough

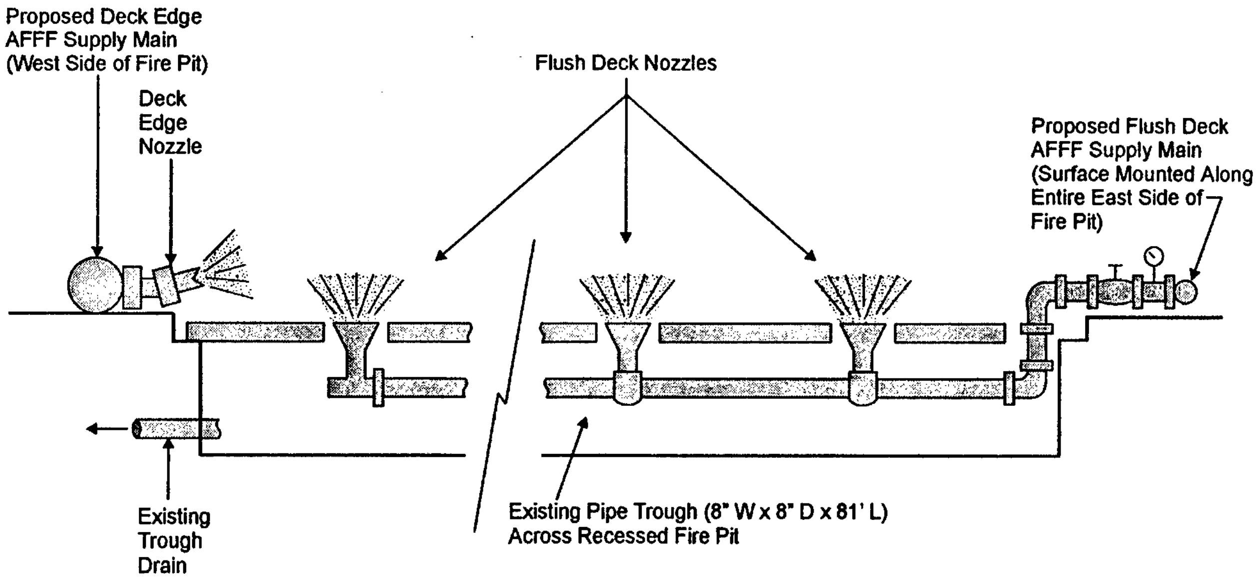

Figure 10 – Proposed nozzle installation method

6.3 "Mini-Deck" Recommended Actions

The following actions should be undertaken to up-grade the China Lake "mini-deck" so it will be an acceptable test bed for future flight deck firefighting assessments:

- Confirm the long-term viability of the existing oil/water separator.
- Conduct a flow test of the hydrant to assure adequate flow and pressure.
- Provide a wind generator to simulate normal flight deck winds during launch and recovery.
- Determine the ability of the existing concrete in the fire test area to resist penetration by fuel and AFFF. Make repairs as necessary to assure an impermeable test surface.
- Provide adequate pumping capacity at the site, assuming simultaneous flow from flush deck nozzles, deck edge nozzles, and hoselines.
- Confirm functionality of existing water/AFFF tanks. Repair or replace as necessary.
- Install a flush deck and deck edge nozzle system (flush deck should include nozzles in both the fire area and a simulated "upwind zone").
- Install simulated carrier flight deck hose stations (reels and racks).

7.0 CONCLUSIONS

It is likely that future CVNX flight deck vulnerability assessments and/or LFT&E surrogate testing will require large-scale fire test evolutions. Flight deck testing and analysis has been tentatively scheduled for FY-07. It would be prudent to initiate detailed design and construction of an appropriate test bed at least two years prior to anticipated testing. As a baseline for analysis purposes, such a test bed should replicate the firefighting features installed in the latest *Nimitz*-class carriers. This report outlines the desirable attributes of such a facility. It appears that the existing "mini-deck" at China Lake could be up-graded to serve as an appropriate test venue.

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